

What is Claimed is:

1. A laser scanning system comprising:

a laser light source emitting a laser light beam;

an optical subsystem, including at least one diffractive optical element, that directs a first portion of the laser light beam into a scanning region and directs a second portion of the laser light beam to an optical detector, wherein the optical detector generates a first electrical signal in response thereto;

a temperature control element, in thermal contact with the laser light source, that is capable of adjusting temperature of the laser light source;

signal processing and control circuitry, operably coupled between the optical detector and the temperature control element, that generates a second electrical signal representing change in characteristic wavelength of the laser light beam emitted from the laser light source based upon the first electrical signal, and controls the temperature control element to adjust temperature of the laser light source based upon the second electrical signal.

2. The system of claim 1, wherein temperature adjustment of the laser light source results in a decrease in variation of the characteristic wavelength of the laser light source.

3. The system of claim 1, wherein a zeroth order beam is produced by the at least one diffractive optical element, and wherein the optical detector is aligned with the zeroth order beam.

4. The system of claim 1, wherein the laser light source comprises a visible laser diode.

5. The system of claim 4, wherein the visible laser diode comprises at least one solid-state lasing element.

6. The system of claim 1, wherein the diffractive optical element comprises a holographic optical element that directs light reflected off surfaces in the scanning region along a return optical path to at least one photodetector, wherein signal processing circuitry analyzes signals generated by the at least one photodetector in response to light received along the return optical path.

7. The system of claim 6, wherein the optical subsystem comprises a rotating disc with multiple holographic optical elements disposed thereon for generating a scan pattern through the scanning region.

8. The system of claim 1, wherein the laser light source and optical subsystem generate at least one AM modulated laser beam for generating range data characterizing at least one spatial dimension of objects passing through scanning region.

9. The system of claim 8, wherein the at least one spatial dimension comprises a profile, volume, or velocity of the object passing through the scanning region.

10. The system of claim 1, wherein the optical detector comprises at least one photodiode device.

11. The system of claim 1, wherein the temperature control element utilizes an active heating element and a passive cooling element.

12. The system of claim 11, wherein the active heating element comprises a resistor in thermal contact with the laser light source.

13. The system of claim 11, wherein the passive cooling element comprises a heat sink in thermal contact with the laser light source, wherein the heat sink passively dissipates heat to ambient air.

14. The system of claim 1, wherein the temperature control element of the system comprises a resistive element affixed to a heat sink in thermal contact with the laser light source.

15. The system of claim 14, wherein temperature of the laser light source is adjusted by varying power supplied to said resistive element.

16. The system of claim 14, wherein temperature of the laser light source is adjusted by varying duty cycle of a pulse modulated power signal supplied to said resistive element.

17. The system of claim 1, wherein the temperature control element comprises a thermoelectric device in thermal contact with the laser light source.

18. The system of claim 1, wherein the signal processing and control circuitry controls the temperature control element to adjust temperature of the laser light source in the event that the second electrical signal exceeds a predetermined threshold value.

19. The system of claim 18, wherein the signal processing and control circuitry comprises a high gain amplifier for amplifying the first electrical signal.

20. The system of claim 19, wherein the signal processing and control circuitry comprises at least one AC coupling capacitor, operatively coupled between the optical detector and the high gain amplifier, for eliminating the coupling of DC noise therebetween.

21. The system of claim 18, wherein the signal processing and control circuitry generates third and fourth electrical signals based upon the first electrical signal, the third electrical signal representing an average wavelength of the laser light beam over a predetermined time period, and the fourth electrical signal representing current wavelength of the laser light beam.

22. The system of claim 21, wherein the signal processing and control circuitry comprises a first RC network, coupled to an output of the high gain amplifier, that generates the third electrical signal.

23. The system of claim 21, wherein the signal processing and control circuitry comprises a first comparator, whose inputs are supplied with the third and fourth electrical signals and whose output is coupled to a second RC network.

24. The system of claim 23, wherein signal processing and control circuitry generates the second electrical signal representing change in characteristic wavelength of the laser light beam emitted from the laser light source based upon output of the second RC network.

25. The system of claim 24, wherein the signal processing and control circuitry comprises a second comparator that compares the second electrical signal and a predetermined threshold signal, and outputs a binary mode switching signal indicating whether the second electrical signal representing change in characteristic wavelength of the laser light beam emitted from the laser light source exceeds the predetermined threshold signal.

26. The system of claim 25, wherein the binary mode switching signal is supplied to a microcontroller programmed to execute a control routine that controls the temperature control element to adjust temperature of the laser light source in response to the logic level of the binary mode switching signal.

27. The system of claim 21, wherein the signal processing and control circuitry comprises analog to digital conversion circuitry for converting the third and fourth signals to digital values, and wherein the digital values are output to a microcontroller programmed to execute a control routine that:

i) generates the second electrical signal, in digital form, representing change in characteristic wavelength of the laser light beam emitted from the laser light source based upon the digital values supplied from the analog to digital conversion circuitry; and

ii) upon determining that the second electrical signal exceeds the predetermined threshold value, controls the temperature control element to adjust temperature of the laser light source in response thereto.

28. The system of claim 18, wherein the signal processing and control circuitry generates a binary mode switching signal indicating whether the second electrical signal representing change in characteristic wavelength of the laser light beam emitted from the laser light source exceeds the predetermined threshold value, wherein the binary mode switching signal is supplied to a microcontroller programmed to execute a control routine that controls the temperature control element to adjust temperature of the laser light source in response to the logic level of the binary mode switching signal.

29. The system of claim 28, wherein the control routine, in response to the logic level of the binary mode switching signal indicating that a change in characteristic wavelength of the laser light source occurred in the last sampling period, controls the temperature control element to heat the laser light source.

30. The system of claim 29, wherein maximum power is applied to the temperature control element in heating the laser light source.

31. The system of claim 29, wherein the control routine, controls the temperature control element to maintain temperature when the logic level of the binary mode logic level of the binary mode switching signal indicates that a change in characteristic wavelength of the laser light source did not occur in the last sampling period.

32. The system of claim 31, wherein a lookup table is used to generate the control signal supplied to the temperature control element in order to maintain temperature.

33. The system of claim 32, wherein the control signal values stored in the lookup table is based upon the control signal value when mode switching begins and the time duration of mode switching.

34. The system of claim 29, wherein the control routine operates, in response to reaching a maximum control value, to switch direction in adjusting temperature of the laser light source to thereby cool the laser light source to bring the laser light source out of mode switching.

35 The system of claim 28, wherein the control routine, in response to the logic level of the binary mode switching signal indicating that a change in characteristic wavelength of the laser light source occurred in the last sampling period, controls the temperature control element to cool the laser light source.

36. The system of claim 35, wherein the control routine controls cooling of the laser light source by applying minimum power to an active heating element, to thereby allow a passive cooling element to cool the laser light source.

37. The system of claim 35, wherein the control routine, controls the temperature control element to maintain temperature when the logic level of the binary mode logic level of the binary mode switching signal indicates that a change in characteristic wavelength of the laser light source did not occur in the last sampling period.

38. The system of claim 37, wherein a lookup table is used to generate the control signal supplied to the temperature control element in order to maintain temperature.

39. The system of claim 38, wherein the control signal values stored in the lookup table is based upon the control signal value when mode switching begins and the time duration of mode switching.

40. The system of claim 29, wherein the control routine operates, in response to reaching a minimum control value, to switch direction in adjusting temperature of the laser light source to thereby heat the laser light source to bring the laser light source out of mode switching.

41. A method for controlling wavelength of a laser light beam emitted from a laser light source in a laser scanning system comprising an optical subsystem, including at least one diffractive optical element, that directs a first portion of the laser light beam into a scanning region, the method comprising the steps of:

directing a second portion of the laser light beam to an optical detector, wherein the optical detector generates a first electrical signal in response thereto;

providing a temperature control element, in thermal contact with the laser light source, that is capable of adjusting temperature of the laser light source;

processing the first electrical signal to generate a second electrical signal representing change in characteristic wavelength of the laser light beam emitted from the laser light source based upon the first electrical signal; and

executing a control routine that controls the temperature control element to adjust temperature of the laser light source based upon the second electrical signal.

42. The method of claim 41, wherein temperature adjustment of the laser light source results in a decrease in variation of the wavelength of the laser light source.

43. The method of claim 41, wherein a zeroth order beam is produced by the at least one diffractive optical element, and wherein the optical detector is aligned with the zeroth order beam.

44. The method of claim 41, wherein the laser light source comprises a visible laser diode.

45. The method of claim 44, wherein the visible laser diode comprises at least one solid-state lasing element.

46. The method of claim 41, wherein the diffractive optical element comprises a holographic optical element that directs light reflected off surfaces in the scanning region along a return optical path to at least one photodetector, and wherein signal processing circuitry analyzes signals generated by the at least one photodetector in response to light received along the return optical path.

47. The method of claim 46, wherein the optical subsystem comprises a rotating disc with multiple holographic optical elements disposed thereon for generating a scan pattern through the scanning region.

48. The method of claim 41, wherein the laser light source and optical subsystem generate at least one AM modulated laser beam for generating range data characterizing at least one spatial dimension of objects passing through scanning region.

49. The method of claim 48, wherein the at least one spatial dimension comprises a profile, volume, or velocity of the object passing through the scanning region.

50. The system of claim 41, wherein the optical detector comprises at least one photodiode device.

51. The method of claim 41, wherein the temperature control element utilizes an active heating element and a passive cooling element.

52. The method of claim 51, wherein the active heating element comprises a resistor in thermal contact with the laser light source.

53. The method of claim 51, wherein the passive cooling element comprises a heat sink in thermal contact with the laser light source, wherein the heat sink passively dissipates heat to ambient air.



54. The method of claim 41, wherein the temperature control element of the system comprises a resistive element affixed to a heat sink in thermal contact with the laser light source.

55. The method of claim 54, wherein temperature of the laser light source is adjusted by varying power supplied to said resistive element.

56. The method of claim 54, wherein temperature of the laser light source is adjusted by varying duty cycle of a pulse modulated power signal supplied to said resistive element.

57. The method of claim 41, wherein the temperature control element comprises a thermoelectric device in thermal contact with the laser light source.

58. The method of claim 41, wherein temperature of the laser light source is adjusted in the event that the second electrical signal exceeds a predetermined threshold value.

59. The method of claim 41, wherein the second electrical signal is generated by amplifying the first electrical signal.

60. The method of claim 59, wherein the second electrical signal is generated by at least one AC coupling capacitor, operatively coupled between an optical detector and the high gain amplifier, for eliminating the coupling of DC noise therebetween.

61. The method of claim 58, further comprising the step of generating third and fourth electrical signals based upon the first electrical signal, the third electrical signal representing an average wavelength of the laser light beam over a predetermined time period, and the fourth electrical signal representing current wavelength of the laser light beam.

62. The method of claim 61, wherein the third electrical signal is generated by a first RC network coupled to the output of the high gain amplifier.

63. The method of claim 61, further comprising the step of comparing the third and fourth electrical signals.

64. The method of claim 63, wherein the second electrical signal representing change in characteristic wavelength of the laser light beam emitted from the laser light source is based upon output of the comparing step.

65. The method of claim 64, further comprising the step of comparing the second electrical signal and a predetermined threshold signal, and outputting a binary mode switching signal indicating whether the second electrical signal representing change in characteristic wavelength of the laser light beam emitted from the laser light source exceeds the predetermined threshold signal.

66. The method of claim 65, wherein the binary mode switching signal is supplied to a microcontroller programmed to execute the control routine that controls the temperature control element to adjust temperature of the laser light source in response to the logic level of the binary mode switching signal.

67. The method of claim 61, further comprising the step of converting the third and fourth signals to digital values, and wherein the digital values are output to a microcontroller programmed to execute a control routine that:

- i) generates the second electrical signal, in digital form, representing change in characteristic wavelength of the laser light beam emitted from the laser light source based upon the digital values supplied from the analog to digital conversion circuitry; and

- ii) upon determining that the second electrical signal exceeds the predetermined threshold value, controls the temperature control element to adjust temperature of the laser light source in response thereto.

68. The method of claim 58, further comprising the step of generating a binary mode switching signal indicating whether the second electrical signal representing change in characteristic wavelength of the laser light beam emitted from the laser light source exceeds the

predetermined threshold value, wherein the binary mode switching signal is supplied to a microcontroller programmed to execute a control routine that controls the temperature control element to adjust temperature of the laser light source in response to the logic level of the binary mode switching signal.

69. The method of claim 68, wherein the control routine, in response to the logic level of the binary mode switching signal indicating that a change in characteristic wavelength of the laser light source occurred in the last sampling period, controls the temperature control element to heat the laser light source.

70. The method of claim 69, wherein maximum power is applied to the temperature control element in heating the laser light source.

71. The method of claim 69, wherein the control routine, controls the temperature control element to maintain temperature when the logic level of the binary mode logic level of the binary mode switching signal indicates that a change in characteristic wavelength of the laser light source did not occur in the last sampling period.

72. The method of claim 71, wherein a lookup table is used to generate the control signal supplied to the temperature control element in order to maintain temperature.

73. The method of claim 72, wherein the control signal values stored in the lookup table is based upon the control signal value when mode switching begins and the time duration of mode switching.

74. The method of claim 69, wherein the control routine operates, in response to reaching a maximum control value, to switch direction in adjusting temperature of the laser light source to thereby cool the laser light source to bring the laser light source out of mode switching.

75. The method of claim 68, wherein the control routine, in response to the logic level of the binary mode switching signal indicating that a change in characteristic wavelength of the

laser light source occurred in the last sampling period, controls the temperature control element to cool the laser light source.

76. The method of claim 75, wherein the control routine controls cooling of the laser light source by applying minimum power to an active heating element, to thereby allow a passive cooling element to cool the laser light source.

77. The method of claim 75, wherein the control routine, controls the temperature control element to maintain temperature when the logic level of the binary mode logic level of the binary mode switching signal indicates that a change in characteristic wavelength of the laser light source did not occur in the last sampling period.

78. The method of claim 77, wherein a lookup table is used to generate the control signal supplied to the temperature control element in order to maintain temperature.

79. The method of claim 78, wherein the control signal values stored in the lookup table is based upon the control signal value when mode switching begins and the time duration of mode switching.

80. The method of claim 69, wherein the control routine operates, in response to reaching a minimum control value, to switch direction in adjusting temperature of the laser light source to thereby heat the laser light source to bring the laser light source out of mode switching.